ZONATION OF BRYOPHYTES IN THE HEADWATERS OF A NEW HAMPSHIRE STREAM

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A vertical zonation of bryophytes on the rocks of the Fox Pond inlet in Plymouth, N.H., is apparent. Here, *Fontinalis novae-angliae* covers the submerged portion while the exposed rock grades from *Plagiochila asplenioides* just above *F. novae-angliae* to Hypnaceae and *Mnium* on the uppermost portions. This gradation suggests the possibilities of moisture, light, or temperature gradients as causal factors, while submersion in high water seasons may also play a part.

Also apparent in this stream is the dominance of *Scapania undulata* at upstream locations and a shift to *Fontinalis novae-angliae* and *Plagiochila asplenioides* farther downstream.

During the late winter of 1969, the inlet of Fox Pond, Plymouth, Grafton Co., N.H., was selected as a study stream for two reasons: its proximity to the campus laboratory and its lush growth of bryophytes which could be used for descriptive studies.

To determine the relative abundance of the *Fontinalis* species and the several accompanying liverwort species, random observation stations were chosen and labelled from the source to a selected point downstream. This selected point marks the beginning of a stream drift study area and it seemed desirable to keep the two areas separate. Stations were chosen by placing the numbers 1-10 in a bucket, drawing a number, multiplying that by five, and taking that many paces to the next station. For example, station AA was placed at the most distal spring of the headwaters, and a 7 was drawn, so station BB was 35 paces downstream. Since the same researcher marked the paces each time, the distances between stations are approximately comparable and the procedure is an expedient one. By this

procedure, seventeen stations (AA-QQ) were chosen. Further downstream twelve stations (A-L) had previously been selected by the same procedure, giving a total of 29 stations. A station extends 2.5 m. on each side of the station label, which is painted on a nearby tree.

Observations were made on September 13 and 15, 1969, at each of the 29 stations, the dominant bryophytes were identified and their locations noted from headwater downstream.

The general trend shows a lack of aquatic bryophytes in the extreme headwaters, but it is not far (about 80 m. at the lower end of EE) before *Fontinalis novae-angliae* Sull. appears, along with several species of leafy liverworts. At this point also, *F. antipyretica* Hedw. var. *gigantea* (Sull.) Sull. occurs, one of two locations for the plant in this stream. As soon as submerged rocks appear in the stream, *F. novae-angliae* dominates the water, while *Scapania undulata* (L.) Dum. grows just beneath the surface and on the wet exposed surface of rocks, while higher parts of the rocks exhibit *Plagiochila asplenioides* (L.) Dum. or *S. nemorosa* (L.) Dum. Farther downstream *P. asplenioides* replaces *S. nemorosa* and a clear line of demarcation appears where *P. asplenioides* meets *F. novae-angliae*. It is in this same region that *F. novae-angliae* becomes a dominant ground cover in the stream, blanketing 50-100% of the stream bottom. There is almost no intermingling of *P. asplenioides* and *F. novae-angliae*, and on the date of observation *P. asplenioides* was always out of the water. However, observations during winter and spring of 1969 showed that many areas of *P. asplenioides* were submerged. Farther down stream, especially on the larger rocks which occur there, a 3-layered zonation appears, typically *F. novae-angliae* — *P. asplenioides* — *Mnium* & Hypnaceae, including *Thuidium delicatulum* (Hedw.) BSG. Occasional clumps of *F. dalecarlica* Schimp. ex. BSG occur, but never reach abundance.

Several factors can be important in determining the location of these bryophytes, and the perfectly repetitive zonation pattern of *F. novae-angliae* to *P. asplenioides* in

the last 14 stations is clearly not one of chance. Observations of the conditions surrounding these plants during two extreme seasons (late winter and late summer) indicate that water level at critical times, coupled with summer humidity, may account for the locations. At all stations, *Fontinalis* was wet, although it was not always submerged during September. Furthermore, at no station was any *P. asplenioides* submerged in summer. But the occurrence of *P. asplenioides* under water for a 2-3 week period in the spring is probably one of tolerance, not of requirement, for *P. asplenioides* is known from soil-covered walls and slopes of open mountain woods (Watson, 1963), which are not likely to ever be submerged. On the other hand, its ability to tolerate the scouring effect of snow melted, debris-filled water could be a competitive advantage over the hypnaceous bryophytes of the upper rock surfaces. When I felt the bryophytes, a humidity gradient was apparent between these two zones on the rocks at the selected stations, and *P. asplenioides* was always damp. The Hypnaceae, with their compact, adnate growth form (smooth mat, Gimingham & Birse, 1957), grow on the drier upper portions of the rocks while *P. asplenioides* (tall turf, Gimingham & Birse, 1957) enjoys the greater humidity of the lower areas. Mr. Luna B. Witton, the owner of the property, states that the stream had much more water than usual in 1969, so the moisture stress on the exposed upper parts of the rocks would likely be much greater in other years. Nevertheless, these are only speculations, and it may well be that a temperature gradient is a more important factor, where one would expect the extremes to occur on the higher parts of rocks, while the most moderate temperatures would be in the water. Or, zones could be related to light intensity, or interaction of all these factors, as suggested by Gimingham & Birse (1957) in their study of vertical zones of stream banks.

Further speculation might suggest that the abundance of *Scapania undulata* and *S. nemorosa* upstream and their replacement by *P. asplenioides* downstream could be related to the more stable water level farther upstream. In a pre-

vious study (Glime, 1968), I indicated that *Scapania undulata* grows in Garrett Co., Maryland, on the brink of waterfalls, and in Carbon Co., Pennsylvania, on the water-air interface zones of rocks and boulders. Its areas of occurrence appear to be areas which keep it constantly soaked, while its terrestrial counterpart, *S. nemorosa*, grows high enough on the rocks to be rarely submerged.

Now at least we know that zonations exist, we have several hypotheses to test, and we can proceed to experimental work and detailed data to test these hypotheses.

Voucher specimens are filed in the DePauw University Herbarium, Greencastle, Indiana.

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